

Patent Claims

1. Shell-and-tube type reactor for carrying out catalytic gaseous phase reactions, comprising a contact tube bundle (8) through which the relevant reaction gas mixture flows and which contains a catalytic filling, extends between two tube sheets (4, 148) and is flushed by a heat transfer medium inside a surrounding reactor shell (6), and further comprising a gas intake and a gas output hood (2; 60) spanning the two tube sheets for administering the relevant process gas to the contact tubes or evacuating the reacted process gas from the contact tubes, characterised in that it together with all of its parts coming into contact with the process gas are arranged for stability in such a way as to withstand all deflagration or event detonation pressures envisaged for its operation.

2. Shell-and-tube type reactor according to Claim 1, characterised in that the volume of space available to the process gas prior to its entry into the contact tubes has been kept to a minimum according to design and technical flow vantage points.

3. Shell-and-tube type reactor according to Claims 1 or 2, characterised in that in the space volume available to the process gas prior to its entry into the contact tubes, dead spaces, in which the process gas could fully or partially come to rest, are avoided as far as possible from design and technical-flow vantage points.

4. Shell-and-tube type reactor according to one of the previous Claims, characterised in that where, inside the space available to the process gas prior to its entry into the contact tubes, dead spaces, in which the process gas could fully or partially come to rest, are inevitable from design and technical flow vantage points, a flushing gas which is inert in relation to the relevant reaction is injected.

5. Shell-and-tube type reactor according to Claim 4, characterised in that flushing gas is radially injected outside of the contact tube bundle (8) at the edge of the tube sheet (4) on the gas intake side.

6. Shell-and-tube type reactor according to Claim 1, characterised in that the flushing gas in question is injected with a tangential flow component.

7. Shell-and-tube type reactor according to one of the previous Claims, characterised in that in administering at least the process gas already ready to react diversions and most especially unevenness are avoided as much as possible.

8. Shell-and-tube type reactor according to one of the previous Claims, characterised in that the gas intake hood (2) is designed flat and funnel-shaped and with a central gas intake.

9. Shell-and-tube type reactor according to Claim 8, characterised in that the gas intake hood (2) is rounded off at least approximately like a trumpet funnel and is designed to flatten out towards the edge.

10. Shell-and-tube type reactor according to one of the Claims 1 through 7, characterised in that in a basically conventional shell-shaped gas intake hood (60) coaxially a flat funnel-shaped fitting (42) is arranged from which a central pass-through is connected sealed up with the gas intake and the edge of which is sealed towards the edge of the tube sheet (4) on the gas intake side.

11. Shell-and-tube type reactor according to Claim 10, characterised in that the fitting (42) is rounded off at least approximately like a trumpet funnel and is designed to flatten out towards the end.

12. Shell-and-tube type reactor according to Claim 10 and 11, characterised in that the fitting (42) is supported at several points, preferably regularly spaced out, on the gas intake hood (60).

13. Shell-and-tube type reactor according to one of the Claims 10 through 12 in connection with Claim 3, characterised in that the sealing (72) on the edge of the fitting (42) is to a limited extent gas-permeable and the flushing gas in question is injected over it.

14. Shell-and-tube type reactor according to Claim 13, characterised in that the sealing (72) in question consists of a partially permeable material such as, for instance, graphite tissue.

15. Shell-and-tube type reactor according to Claim 13, characterised in that the sealing (72) in question has discrete

gas penetration canals such as, for instance, drill holes (92) or furrows (88; 96; 108).

16. Shell-and-tube type reactor according to Claim 13 and 14, characterised that the sealing (72) in question consists of a profile (86; 104; 106) potentially flexible under high pressure.

17. Shell-and-tube type reactor according to one of the Claims 13 through 16, characterised in that the sealing (72) in question is connected on the outside with a space through which the flushing gas is fed.

18. Shell-and-tube type reactor according to Claim 17, characterised in that the space in question is limited by a radially inside seal (72) and a radially outside seal (76).

19. Shell-and-tube type reactor according to Claim 18, characterised in that the flushing gas is under high pressure in relation to the external atmosphere.

20. Shell-and-tube type reactor according to one of the Claims 17 through 19, characterised in that the space in question

basically consists if the residual space of the gas intake hood (60).

21. Shell-and-tube type reactor according to one of the previous Claims, characterised in that the gas intake hood (2; 60), the tube sheet (4) on the gas intake side and/or, where there is one, the relevant fitting (42) are connected to each other via a welded lip seal (76; 122).

22. Shell-and-tube type reactor according to one of the previous Claims, characterised in that the gas intake hood (2; 60) is fastened to the end of the tube sheet (4) on the gas intake side by means of studs.

23. Shell-and-tube type reactor according to one of the previous Claims, characterised in that the gas intake hood (2; 60) and/or its fitting (42) can be cooled and/or heated.

24. Shell-and-tube type reactor according to Claim 23, characterised in that the gas intake hood (2; 60) and/or its fitting (42) has canals (160) through which coolant or heat transfer medium can flow.

25. Shell-and-tube type reactor according to one of the previous Claims, characterised in that on the tube sheet (4) on the gas intake side, pointed towards the gas intake, a spike-shaped flow diverter (16) is arranged narrowing down in that direction.

26. Shell-and-tube type reactor according to one of the previous Claims, characterised in that the tube sheet (4) on the gas intake side is supported on the reactor shell (6) in the direction of the tube sheet (148) on the gas output side.

27. Shell-and-tube type reactor according to Claim 26, characterised in that the support at least in part consists of a metal component which is multi-winged in relation to the reactor's longitudinal axis.

28. Shell-and-tube type reactor according to Claim 26 or 27, characterised in that the metal component essentially consists of at least one diagonally arranged sheet (141).

29. Shell-and-tube type reactor according to Claim 27 or 28 and with a ring-shaped contact tube bundle (8), characterised in that the support consists partially of an additional basically cylindrical, prismatic, conic or pyramid-shaped metal component

in the tubeless interior of the contact tube bundle which in turn is supported on the multi-winged metal component.

30. Shell-and-tube type reactor according to one of the Claims 26 through 29, characterised in that the support has a number of longitudinally aligned pressure relief slots (150) and/or recesses (152).

31. Shell-and-tube type reactor according to one of the Claims 26 through 30, characterised in that the support extends up to the tube sheet (148) on the gas output side.

32. Shell-and-tube type reactor according to one of the Claims 26 through 31, characterised in that the support is loosely joined to the tube sheet (4; 148) in question.

33. Shell-and-tube type reactor according to one of the Claims 26 through 32, characterised in that the support fits into a recess (142) in the tube sheet (4; 148) in question.

34. Shell-and-tube type reactor according to one of the previous Claims, characterised in that the tube sheet (4) on the gas intake side is heat-insulated.

35. Shell-and-tube type reactor according to one of the previous Claims, characterised in that the gas intake hood (2; 60) as used for gas feed-in is successively preceded by a first feed-in point (174) for second process gas component to be added to a first process gas component, possibly followed by a mixer, and then at least one further feed-in point (176; 178; 192) for the rest of the second or an additional process gas component.

36. Shell-and-tube type reactor according to Claim 15, characterised in that at least one mixer (182, 184, 186) follows the last feed-in point.

37. Shell-and-tube type reactor according to one of the Claims 35 and 36, characterised in that at least one second feed-in point of a precision sparging device (192) is formed with a number of sparging units (194) distributed across the cross-section of the canal.

38. Shell-and-tube type reactor according to Claim 37, characterised in that the sparging units (194) are furnished with individual chokes and/or devices producing a twist.

39. Shell-and-tube type reactor according to one of the Claims 35 through 38, characterised in that at least one of the feed-in points (174, 176, 178; 192) is arranged so that the relevant process gas component is absorbed or itself heated-up by it or, possibly, heats up by itself.

40. Shell-and-tube type reactor according to Claim 39, characterised in that the relevant feed-in point (174, 176, 178; 192) has a means of injecting the liquid process gas component.

41. Shell-and-tube type reactor according to Claim 39 or 40, characterised in that the relevant feed-in point (174, 176, 178; 192) is in a position to atomize and/or to vaporize the process gas component in question.

42. Shell-and-tube type reactor according to one of the Claims 35 through 41, characterised in that the feed-in point (174, 176, 178; 192) and/or its administration has heating agents and/or is heat-insulated.

43. Shell-and-tube type reactor according to one of the Claims 35 through 42, characterised in that between the first and the

second feed-in point (172, 174; 194) there is a check valve arrangement (180) present.

44. Shell-and-tube type reactor according to one of the Claims 35 through 43, characterised in that between the first and the second feed-in point (174, 176) there is a pressure reduction space present.

45. Shell-and-tube type reactor according to Claim 44, characterised in that the pressure reduction space is formed at least partially by a chamber (190) housing the check valve arrangement (180).

46. Shell-and-tube type reactor according to one of the previous Claims, characterised in that it can be used for oxidation, hydration, dehydration, nitration, alkylation processes and so forth.

47. Shell-and-tube type reactor according to Claim 45, characterised in that it can be used for the production of ketones, methyl-isobutyl-ketones, mercaptan, isoprene, anthrachinone, o-cresol, ethylene hexane, furfurol, acetylene, vinyl acetate, isopropyl chloride, naphthalene acid anhydride,

vinyl chloride, oxo-alcohol, pyrotol, styrol, methanformic acid nitrile, polyphenylene oxide, dimethylphenol, pyridinaldehyde, Therban, alpha olefins, vitamin B6, prussic acid, aniline, formic acid nitrate, difluoromethane, 4-methyl-2-pentanon and tetrahydrofuran as well as, in particular, the oxidation of dimethylbenzols (m,o,p) into the corresponding monoaldehydes and dialdehydes, oxidation of dimethylbenzols (m,o,p) into the corresponding monocarbonic and dicarbonic acids or their anhydrides, oxidation of trimethylbenzols into the corresponding monoaldehydes, dialdehydes and trialdehydes, oxidation of trimethylbenzols into the corresponding monocarbonic acids, dicarbonic acids and tricarbonic acids or their anhydrides, oxidation of durol into pyromellitic acid anhydride, oxidation of gamma picoline or beta picoline into gamma picoline-carboaldehyd, oxidation of gamma picoline or beta picoline into iso-nicotinic acid or nicotinic acid, oxidation of propene into acrolein, oxidation of acrolein into acrylic acid, oxidation of propane into acrolein, oxidation of propane into acrylic acid,

oxidation of butane into maleic acid anhydride,
oxidation of refined product into maleic acid anhydride,
oxidation of i-butenes into methacrolein,
oxidation of methacrolein into methacrylic acid,
oxidation of methacrolein into methyl-methacrylate, oxidation of
i-butane into methacrolein,
oxidation of i-butane into methacrylic acid,
ammonoxidation of dimethylbenzols (m,o,p) into the corresponding
mononitriles and dinitriles,
ammonoxidation of trimethylbenzols into the corresponding
mononitriles, dinitriles and trinitriles,
ammonoxidation of propane to acrylonitrile,
ammonoxidation of propene into acrylonitrile,
ammonoxidation of beta picoline into 3-cyanopyridine, ammonoxidation
of gamma picoline into 4-cyanopyridine, oxidation of methanol
into formaldehyde,
oxidation of naphthalene and/or o-xylol possibly mixed into
phthalic acid anhydride,
oxidation of ethane into acetic acid,
oxidation of ethanol into acetic acid,
oxidation of geraniol into citral,
oxidation of ethene into ethyloxide,
oxidation of propene into propylene oxide,

oxidation of hydrogen chloride into chlorine,
oxidation of glycol into glyoxal and
hydration of maleic acid anhydride into butane diol.

48. A process for operating a shell-and-tube type reactor according to one of the previous Claims, characterised in that the shell-and-tube type reactor is run in production operations with such a charge of a first process gas component with at least one further process gas component with which occasional deflagrations or even detonations must be reckoned with.

49. A process for operating a shell-and-tube type reactor according to one of the Claims 1 through 47, characterised in that for starting up the reactor the concentrations of the process gas components and possibly additional parameters as well are measured on an ongoing basis in such a way that the violence of deflagrations or even detonations occurring does not exceed that reckoned with for operating conditions.